Warming for Catastrophists Alarmists Warmists Dummies Heretics Skeptics Denialists

Sun-Planet

Planet without Atmosphere

Planet with Atmosphere

Greenhouse and Gases

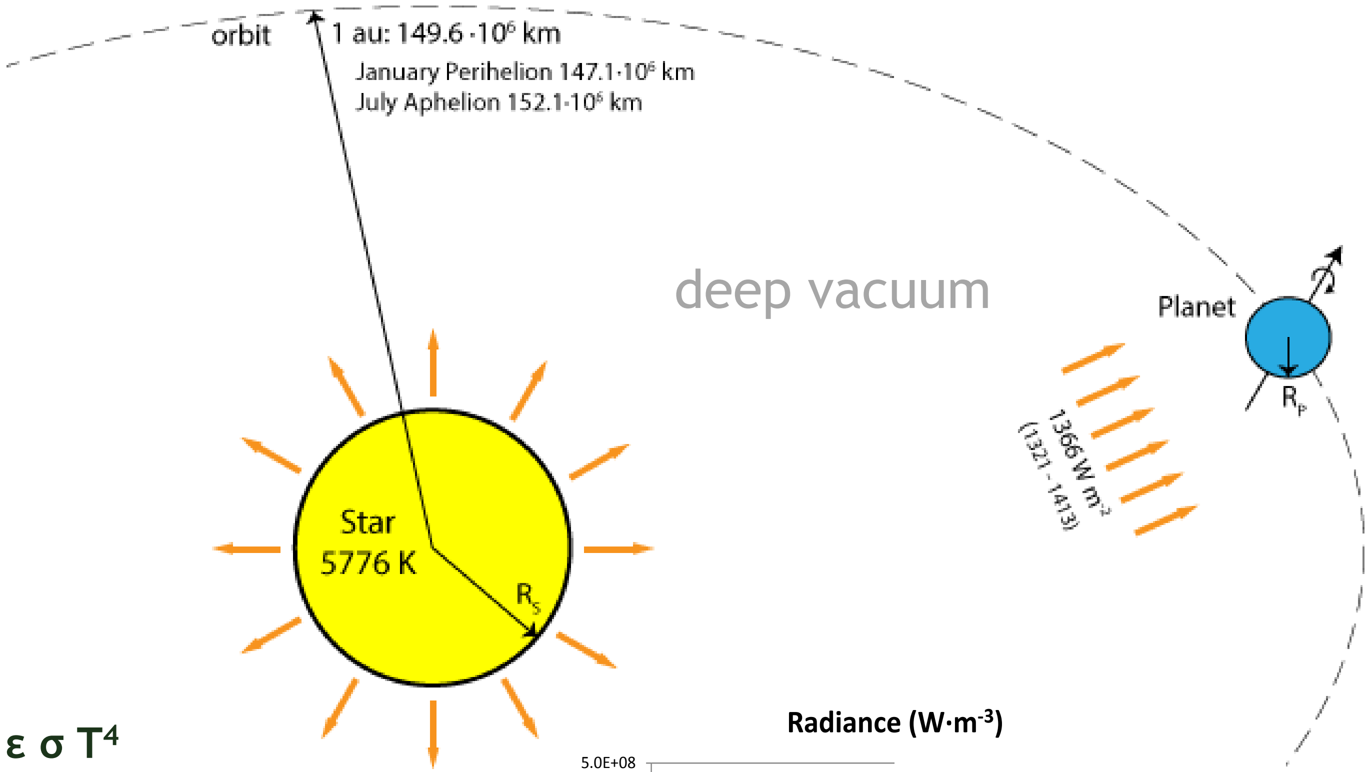
Forcing

Warming with Feedback

Pending Questions

Star-Planet System

One heat source: star's thermonuclear activity
One heat sink: outer space at background temperature 2.8 K
No other heat exchange than electromagnetic radiation

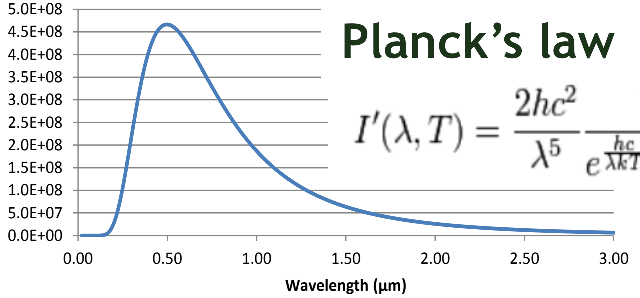


Stefan - Boltzmann: $E = \varepsilon \sigma T^4$

E	Emitted power	$6.31 \cdot 10^{15}$	W m^{-2}
ε	Surface emissivity	1	-
σ	Stefan-Boltzman constant	$5.67 \cdot 10^{-8}$	W m^{-2} K^{-4}
T	Surface temperature	5776	K

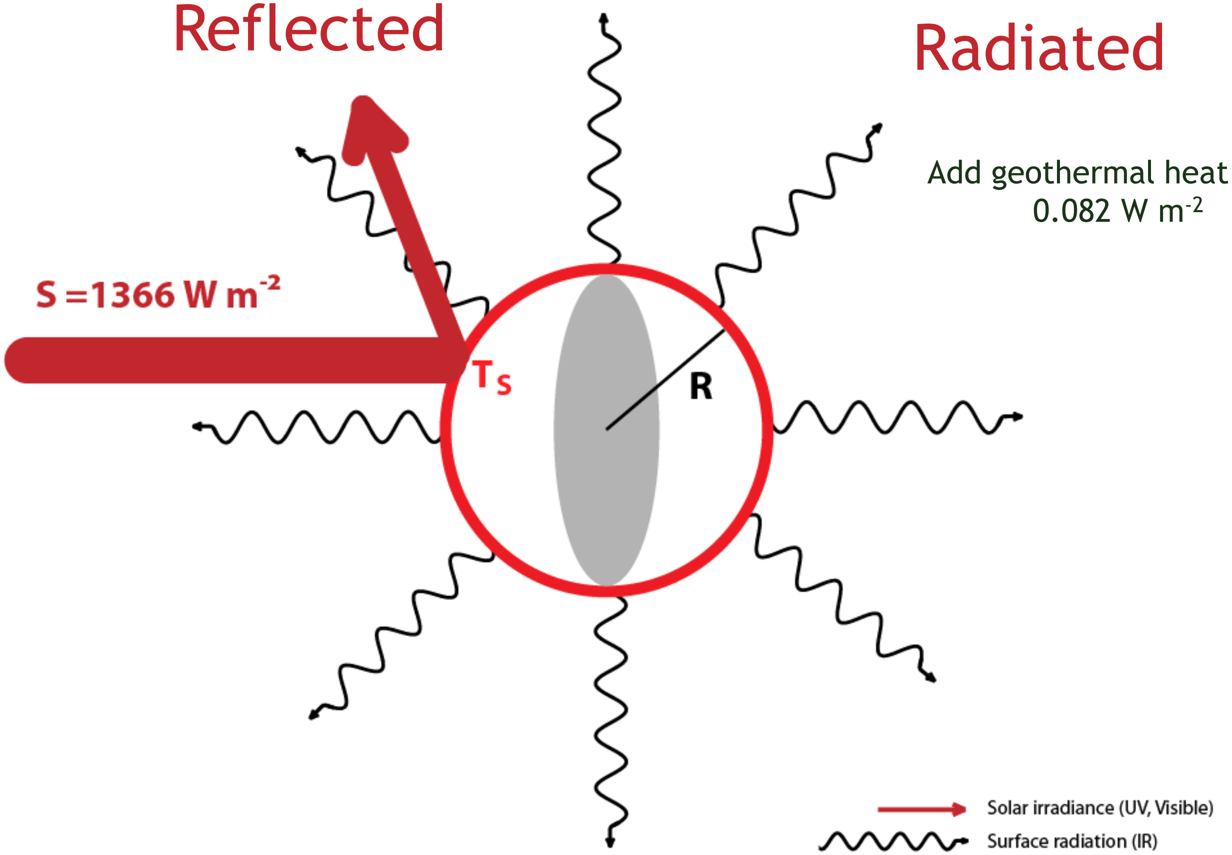
Planck's law

$$I'(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$



Planet without atmosphere

Incoming energy = Outgoing energy



Reflected

Radiated

Add geothermal heat flow
0.082 W m^{-2}

$S = 1366\ \mathrm{W\ m^{-2}}$

Incoming

T_S

R

Solar irradiance (UV, Visible)

Surface radiation (IR)

Menu

Planet without atmosphere

Stefan - Boltzmann: $E = \varepsilon\ \sigma\ T^4$

- No reflection

$$Tsurface = \sqrt[4]{\frac{E}{\varepsilon\ \sigma}} = \sqrt[4]{\frac{341.5}{\sigma}} = 278.6\ K = 5.4\ ℃$$

- 30% reflected, emissivity ε = 0.95

$$Tsurface = \sqrt[4]{\frac{341.5\ \cdot\ (1 - 0.3)}{0.95\ \cdot\ \sigma}} = 258.1\ K = -15.05\ ℃$$

However, mean surface temperature is 14-15 °C ⇨ **ATMOSPHERE !**

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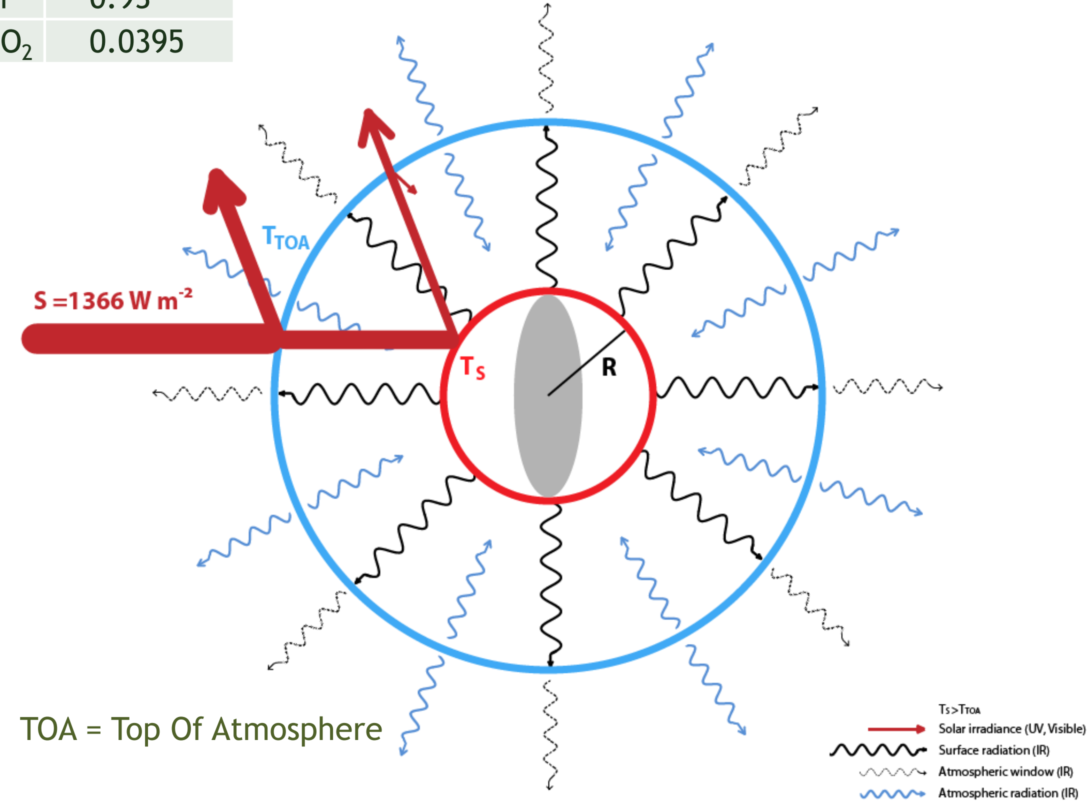
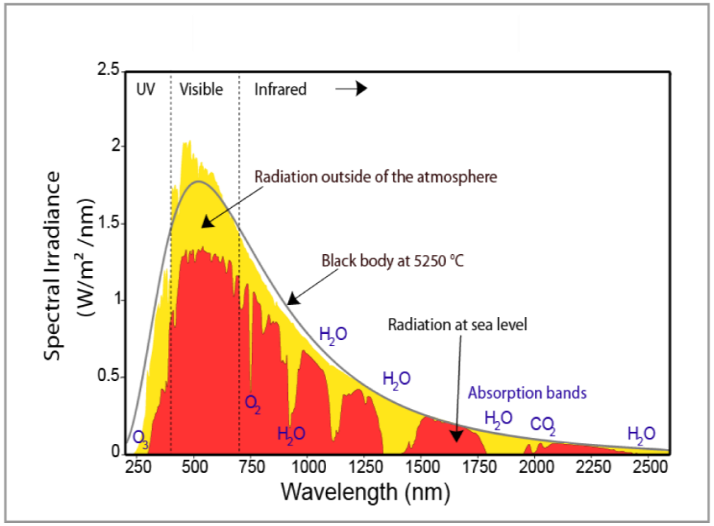
Planet with atmosphere

N_2	78.08 Vol %
O_2	20.95
Ar	0.93
CO_2	0.0395



TOA = Top Of Atmosphere

S Average Day-Night, Poles-Equator:
1366/4 = 341.5 W m^{-2}



2 Layers Model:

$$T_S = \sqrt[4]{\frac{(1-\alpha)\cdot S}{4\cdot\epsilon\cdot\sigma\cdot\left(1-\frac{c}{2}\right)}}$$

$$T_{TOA} = \sqrt[4]{\frac{(1-\alpha)\cdot S}{4\cdot\sigma\cdot(2-c)}}$$

α = albedo (0.3)
ε = emissivity (0.886, 1 for atmosphere)
c = cloudiness (0.6)

	Emitted radiation	Temperature T_S	
	W m^{-2}	K	°C
At the Earth's surface	341.5	287.1	+14.0
At the top of atmosphere TOA	170.8	234.3	-38.9

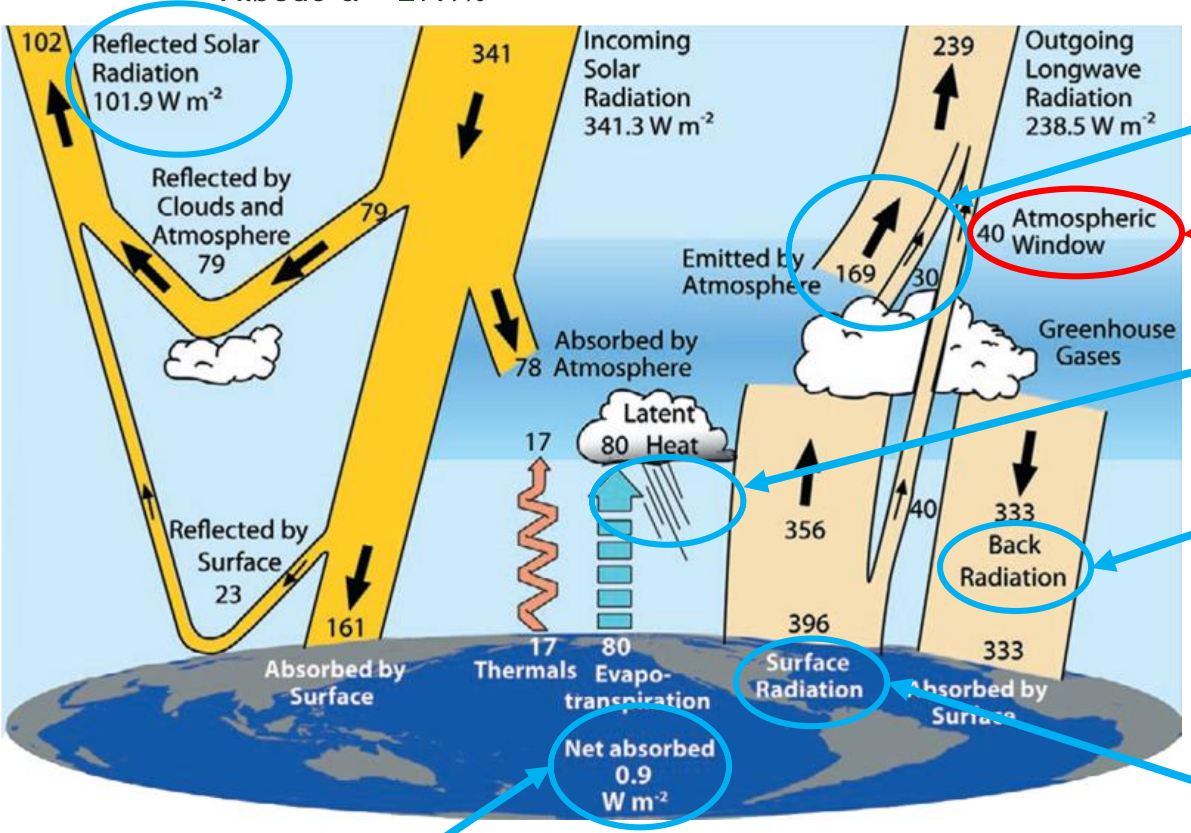
T_S sensitivity:
Variation for +1% albedo -1.03 °C, +1% cloudiness +0.51 °C, and +1% emissivity -.82 °C.

Menu

Planet with atmosphere

KT Diagram

Albedo α = 29.9%



Temperature of a black body emitting 199 W m^{-2} : -30 °C

Radiation emitted from the ground and not reabsorbed by anything else

Rainfalls of 842 mm per year corresponding to 65 W m^{-2}

Cloudy nights feel warmer than with clear sky

Surface radiation at 15 °C with ε =0.886 : 345.6 W m^{-2}
Sensitivity: 4.8 W m^{-2} / K

On-going warming if accumulated, or rather the result of the inaccuracies of all measurements and model calculations.

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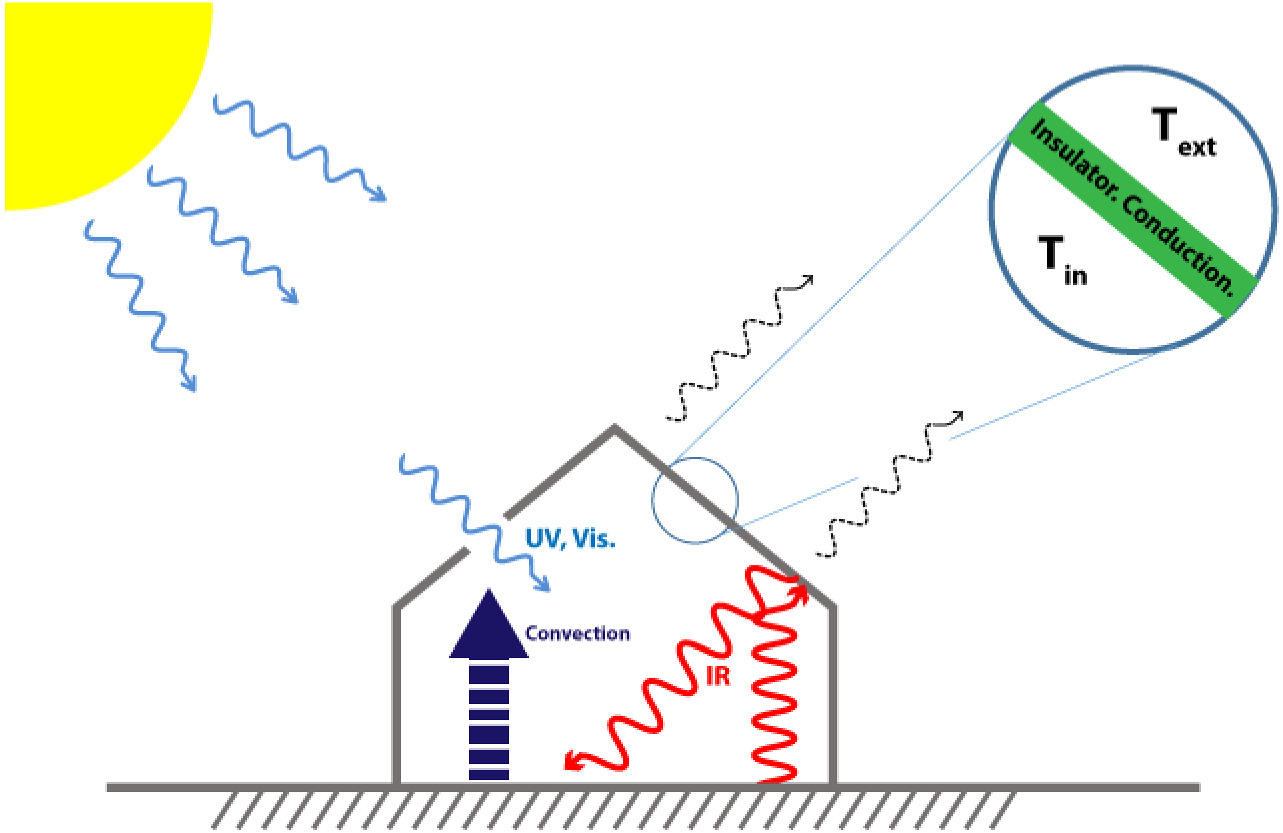
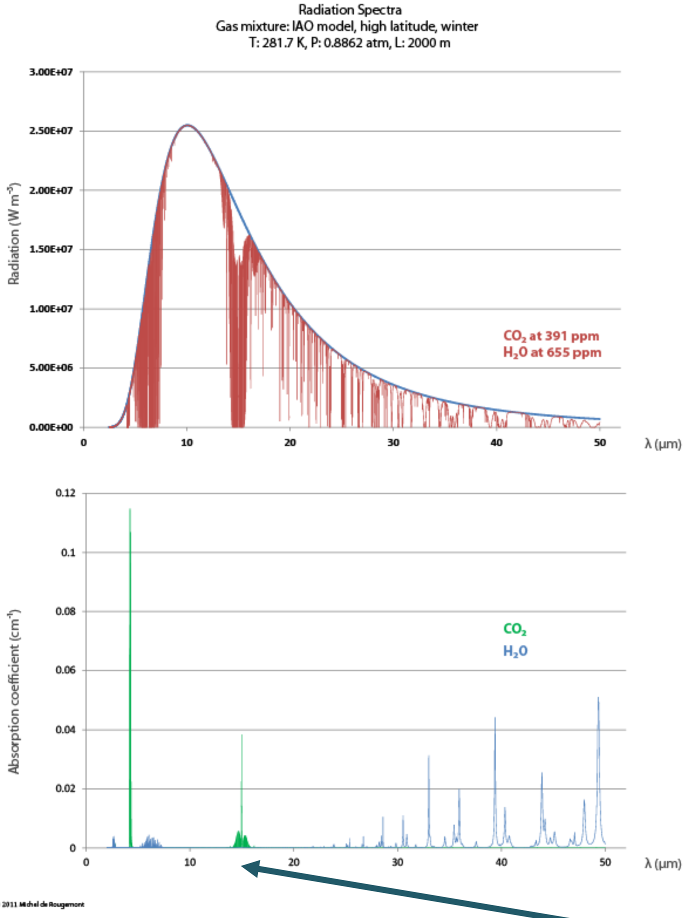
Glasshouse



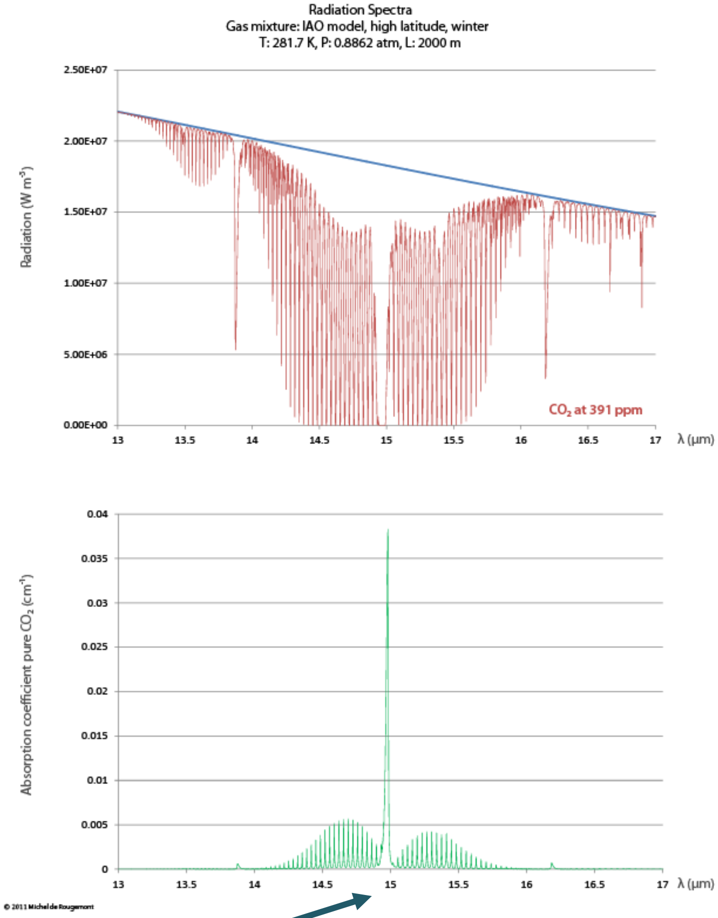
Mechanism: rather warm air trapping than IR absorption

Long Wave IR Absorption by Greenhouse Gases

H_2O : 0-5 %
CO_2 : 400 ppm
CH_4 : 1800 ppb
NO_x : 325 ppb

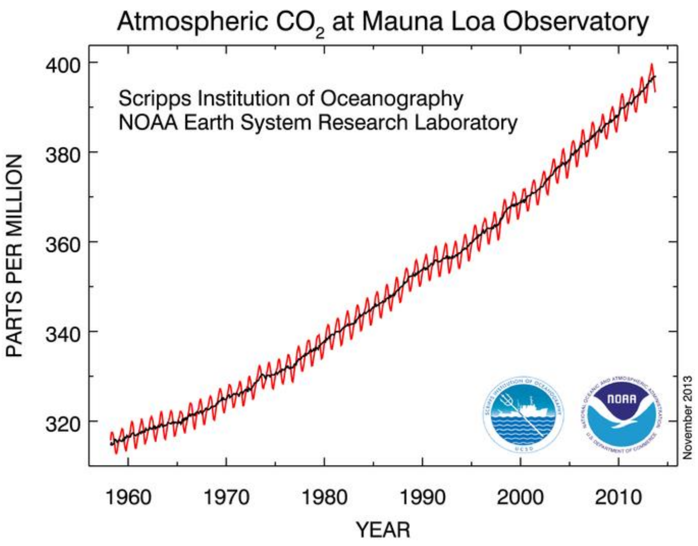


Cold and relatively dry air



Zoom around the 15 µm range

Carbon dioxide CO_2

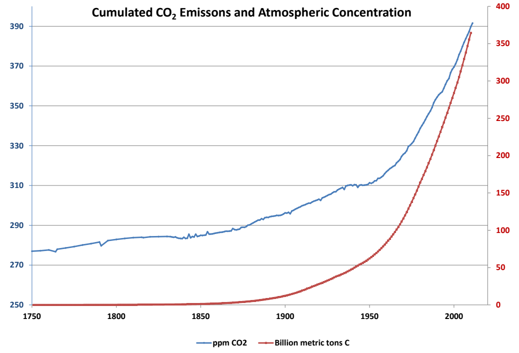


Atmospheric concentration
Rising at ~2 ppm per year

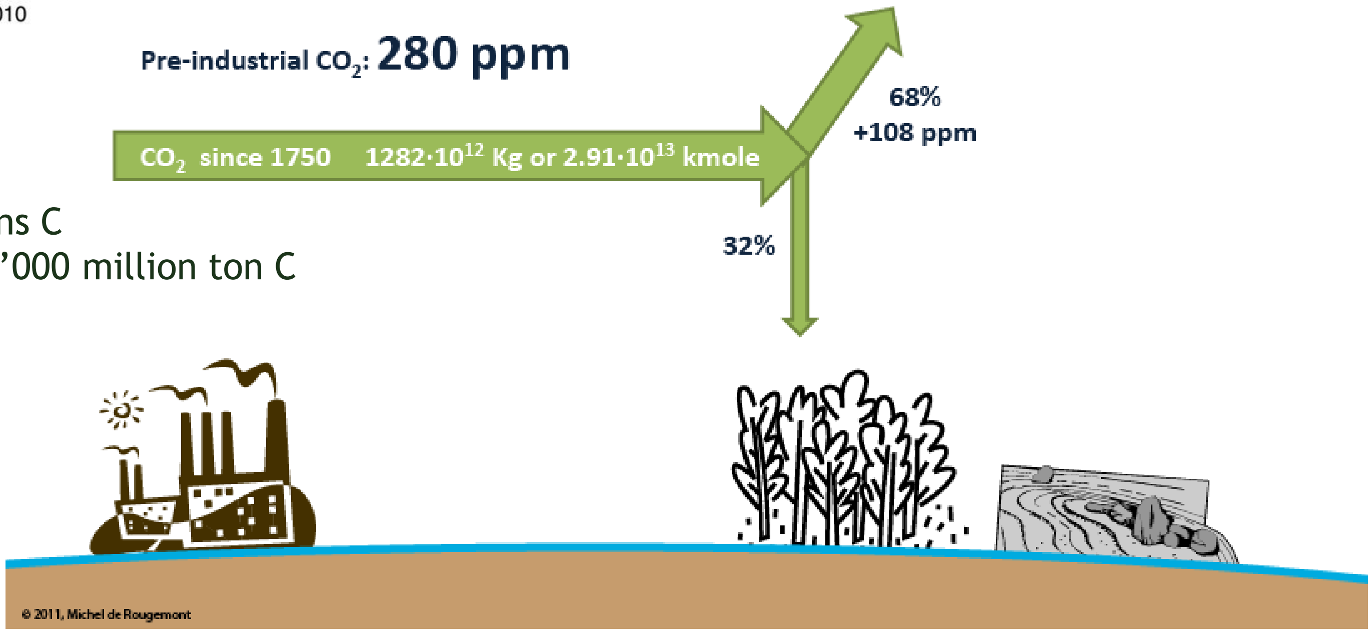
Emitted by fossil fuel combustion $C_xH_y + \left(x + \frac{y}{2}\right) O_2 \rightarrow x\, CO_2 + \left(\frac{y}{2}\right) H_2O$

Captured by photosynthesis, $6\, CO_2 + 6\, H_2O \rightarrow C_6H_{12}O_6 + 6\, O_2$
or dissolution in water, followed by
metabolisation and mineralisation

Emissions
per year approx. 10’000 million tons C
Since beginning industrial era: 370’000 million ton C



Mass balance: approx. 2/3 remain in the atmosphere


Air mass: 5.27·10^{18} Kg or 1.82·10^{17} kmole

CO_2 in 2009: 388 ppm

Pre-industrial CO_2: 280 ppm

68%
+108 ppm
CO_2 since 1750 1282·10^{12} Kg or 2.91·10^{13} kmole
32%
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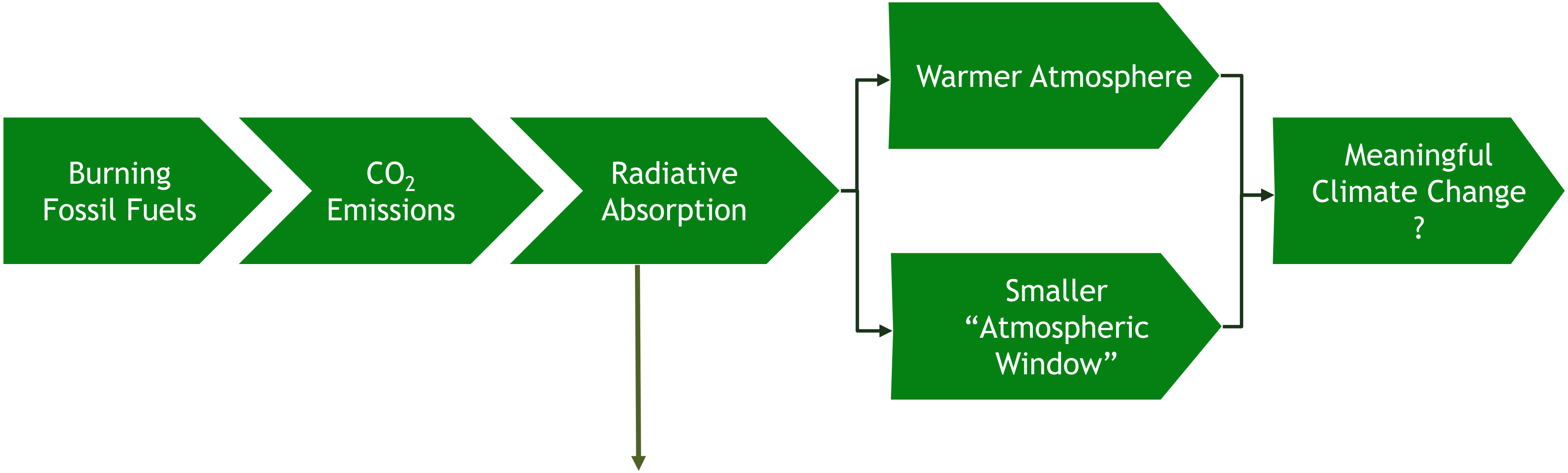
Greenhouse Gas Forcing ⇨ Warming



Burning Fossil Fuels

CO_2 Emissions

Radiative Absorption

Warmer Atmosphere

Smaller “Atmospheric Window”

Meaningful Climate Change ?

$$\boldsymbol{\Delta F = 5.35 \cdot ln\frac{C_1}{C_0} \quad [\,W\,m^{-2}]}$$

(Myhre et al.1998)

For any doubling of CO_2 concentration: $\Delta F = 5.35 \cdot \ln(2) = \mathbf{3.71}\ \mathrm{W\,m^{-2}}$

All GHGs, since beginning industrial era: $\Delta F = 2.75\ \mathrm{W\,m^{-2}}$

Menu

Forcing ΔF ⇨ Warming ΔT

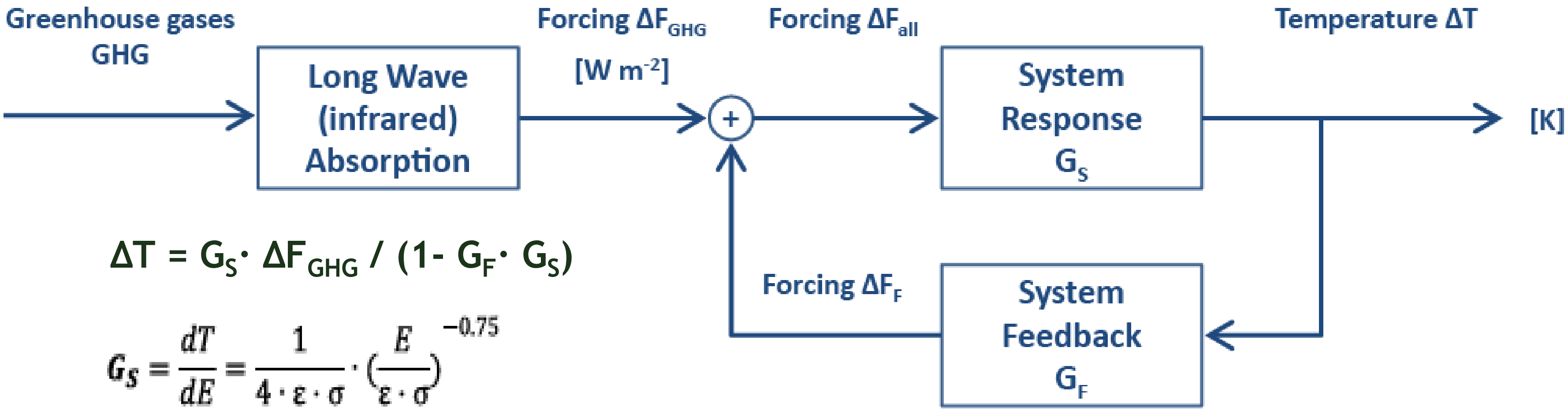
- Impact of a doubling of CO2 concentration
  - At lower altitude:
    - Surface temperature of grey body emitting 341.3 W m^{-2} : 287.1 K or +13.94°C.
    - And if emitting 341.1 + 3.71 = 344.81 W m^{-2} : 287.83 K or +14.67 °C

      a difference of **0.73 K**
  - At higher altitude
    - Surface temperature of black body emitting 199 W m^{-2} : 243.40 K or -29.76 °C.
    - And if emitting 199 + 3.71 = 202.71 W m^{-2} : 244.53 K or -28.64 °C

      a difference of **1.12 K**

- Thus any doubling of the CO_2 concentration may have a primary forcing effect between 0.7 and 1.1 K on the atmosphere temperature, depending on the altitude.

System Feedback to Primary Forcing



Greenhouse gases GHG

Long Wave (infrared) Absorption

Forcing ΔF_{GHG} [W m^{-2}]

Forcing ΔF_{all}

System Response G_S

Temperature ΔT [K]

Forcing ΔF_F

System Feedback G_F

$$\Delta T = G_S \cdot \Delta F_{GHG} / (1 - G_F \cdot G_S)$$

$$G_S = \frac{dT}{dE} = \frac{1}{4 \cdot \varepsilon \cdot \sigma} \cdot \left(\frac{E}{\varepsilon \cdot \sigma}\right)^{-0.75}$$

5 mechanisms, reinforcing if positive, dampening if negative:

Planck effect	$\lambda_P = -3.21 \pm 0.04$ W m^{-2} K^{-1}
Water vapour	$\lambda_{WV} = +1.80 \pm 0.18$ W m^{-2} K^{-1}
Lapse Rate	$\lambda_{LR} = -0.84 \pm 0.26$ W m^{-2} K^{-1}
Albedo	$\lambda_A = +0.26 \pm 0.08$ W m^{-2} K^{-1}
Clouds	$\lambda_C = +0.69 \pm 0.88$ W m^{-2} K^{-1}
In combination:	$\lambda = \lambda_P + \lambda_{WV} + \lambda_{LR} + \lambda_A + \lambda_C = -3.21 + 1.80 - 0.84 + 0.26 + 0.69 =$

$$G_F = \mathbf{-1.30}\ [-0.58 \text{ to } -2.02]\ \mathbf{W\ m^{-2}\ K^{-1}}$$

Forcing ΔT after Feedback

At earth surface:	At higher altitude:
Since beginning of industrial era:	
$\Delta T = 0.21 \cdot 2.75 \,/(1- (-1.3) \cdot 0.21) =$ **0.45 K**	$\Delta T = 0.39 \cdot 2.75 \,/(1- (-1.3) \cdot 0.39) =$ **0.71 K**
For any doubling of CO_2:	
$\Delta T = 0.21 \cdot 3.71 \,/(1- (-1.3) \cdot 0.21) =$ **0.61 K**	$\Delta T = 0.39 \cdot 3.71 \,/(1- (-1.3) \cdot 0.39) =$ **0.96 K**
Without any feedback : **ΔT = 0.73 K**	**ΔT = 1.12 K**

It is therefore difficult to understand why the IPCC continues to expect temperature increase of 1.5 to 4 K.

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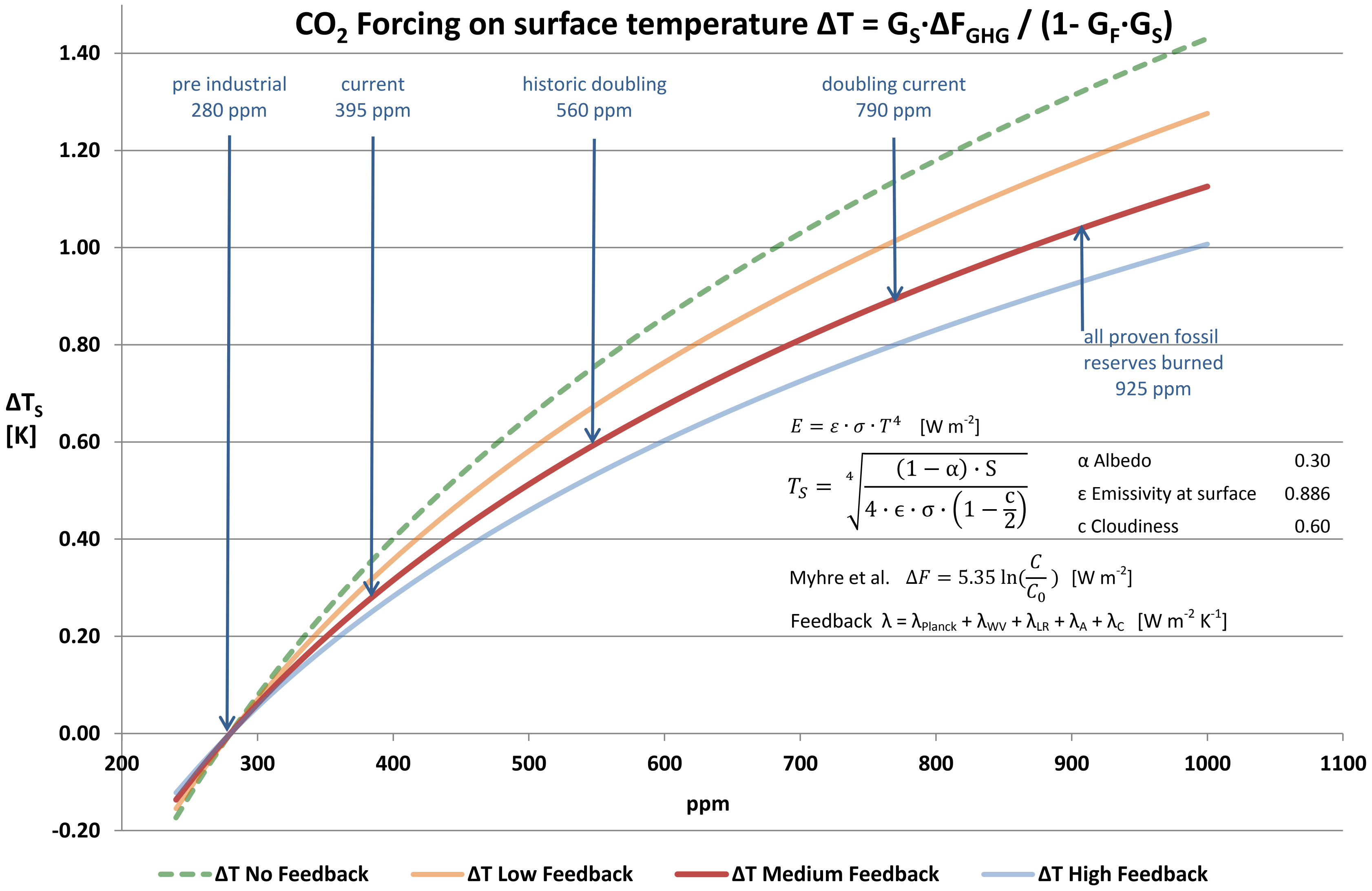
CO_2 Concentration ⇔ ΔT



CO$_2$ Forcing on surface temperature $\Delta T = G_S \cdot \Delta F_{GHG} / (1 - G_F \cdot G_S)$

$E = \varepsilon \cdot \sigma \cdot T^4$ [W m^{-2}]

$$T_S = \sqrt[4]{\frac{(1-\alpha) \cdot S}{4 \cdot \epsilon \cdot \sigma \cdot \left(1 - \frac{c}{2}\right)}}$$

α Albedo	0.30
ε Emissivity at surface	0.886
c Cloudiness	0.60

Myhre et al. $\Delta F = 5.35 \ln(\frac{C}{C_0})$ [W m^{-2}]

Feedback $\lambda = \lambda_{Planck} + \lambda_{WV} + \lambda_{LR} + \lambda_A + \lambda_C$ [W m^{-2} K^{-1}]

Pending questions

- How a balanced model showing modest temperature increases can be blown up to a catastrophe theory?
  - Are there other observed positive feedbacks?
- No statistically significant temperature increase has been observed since 1998.
  - This was not foreseen – nor calculated backwards – by models, why?
  - Isn't it because the role of greenhouse gases was exaggerated?
- The simple static two layer model is consistent with global energy balance
  - how is it with complex, non-linear, dynamic circulation models?
- Would a slight warming of the atmosphere and of the ocean surface meaningfully change our living conditions on Earth?
  - If yes, in a positive or in a negative way?
- Why curb CO_2 emissions while energy is so much needed in emerging and developing regions for their health, well-being, and future capabilities?
  - Ok if only to delay exhaustion of fossil reserves and to become independent from war prone Near and Middle-East region, but in an orderly and economic way.
- Are the next generations going to be so dumb that we need *hic et nunc* to resolve anticipated hypothetical problems in their names?
  - What if such actions were counterproductive? How to know they aren't?
- What is the strategic objective of catastrophe mongers?

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